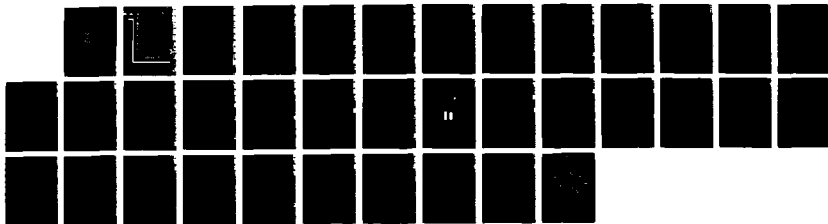


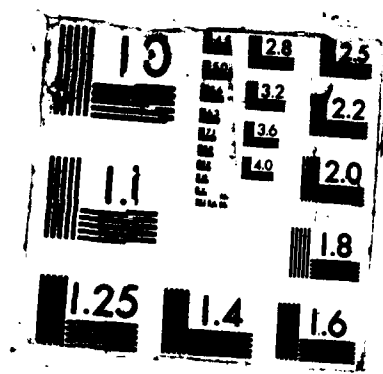
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LOGISTICS COMPOSITE MODEL ANALYSIS
OF A FUTURE GUNSHIP DESIGN

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LOGISTICS AND HUMAN FACTORS DIVISION
Wright-Patterson Air Force Base, Ohio 45433-6503

July 1987

Final Report for Period August 1985 - January 1986

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This report has been reviewed and is approved for publication.

BERTRAM W. CREAM, Technical Director
Logistics and Human Factors Division

HAROLD G. JENSEN, Colonel, USAF
Commander

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) <p>> This report documents the results and methodology used to quantify the sortie generation capability and maintenance manpower requirements for a hypothetical, state-of-the-art gunship. The Logistics Composite (LCOM) model was used to perform this analysis. Analysis showed that a relatively large increase in equipment reliability resulted in a relatively small decrease in maintenance manpower requirements. The conclusion is that equipment reliability improvements alone will not produce significant reductions in maintenance manpower requirements. This must come from the synergistic effect of reliability improvements in conjunction with improvements in other supportability factors such as the maintenance concept, specialty consolidation, aircraft basing mode, and other facilities.</p>			
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SUMMARY

Decisions affecting 85% of the life-cycle cost of a weapon system program are made before full-scale engineering development begins. The Air Force currently lacks adequate methodology to analyze supportability issues during the conceptual design phase. At the request of the Aeronautical Systems Division (ASD), the Air Force Human Resources Laboratory (AFHRL) undertook an analysis of the logistics drivers and impacts of future gunships. This report summarizes the methodology and data used to quantify the sortie generation capability and maintenance manpower requirements for a hypothetical, but representative, state-of-the-art gunship.

The tool used to perform this analysis was the Logistics Composite (LCOM) model. Two representative scenarios, using a hypothetical 30-day deployment of 10 improved gunships flying a minimum of 270 sorties, were used for this analysis. Scenario I involved operations from a Main Operating Base (MOB) and Scenario II involved operations from a Forward Operating Location (FOL). The improved gunship was defined to be a modified version of the current AC-130H gunship. Modifications involved the avionics, communication, navigation, and mission equipment subsystems.

The approach taken was to create an LCOM model of the baseline AC-130H and then modify this model to represent the improved SOF-130 gunship. The unavailability of maintainability data for the improved SOF-130 gunship changed the analysis from a quantification of maintenance manpower requirements to a quantification of the impact of changes in hardware reliability on maintenance manpower requirements. The analysis resulted in a projected generation rate of 284 sorties versus the target rate of 270 for the 30-day period. Maintenance manpower requirements decreased by approximately 5% from the baseline AC-130H aircraft. Low manpower utilization rates occurred for all Air Force Specialty Codes (AFSCs). The primary research result was that a relatively large increase in equipment reliability resulted in a relatively small decrease in maintenance manpower requirements.

The primary conclusion is that quantitatively oriented front-end logistics analyses are possible and that this is a successful demonstration of this Air Force capability. Another conclusion is that equipment reliability improvements alone will not produce significant reductions in maintenance manpower requirements. This must come from the synergistic effect of reliability improvements in conjunction with improvements in other supportability factors such as the maintenance concept, specialty consolidation, aircraft basing mode, and other "ilities" (testability, accessibility, etc.). Recommendations relevant to future gunship development programs are also provided.

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PREFACE

This report documents the results of an in-house Air Force Human Resources Laboratory, Logistics and Human Factors Division (AFHRL/LR) Logistics Composite (LCOM) model assessment of selected logistics requirements for a future gunship. It is one of six resulting from an AFHRL/LR attempt to develop and demonstrate methodologies to perform front-end logistics analyses on a weapon system design in the conceptual phase. As of this time, only one of these six reports has been published. AFHRL-TR-86-21, Sustained Firepower Study: Logistics Requirements for Deployment of an Improved AC-130 Gunship, is a preliminary estimation of selected logistics resources required to support deployment of 10 near-term replacement gunships. Reports still being written address the following four issues:

1. methodology for front-end logistics analysis,
2. results of human factors and training analyses of future gunships,
3. methodology for front-end human factors analyses,
4. executive summary of AFHRL/LR research efforts in analyzing conceptual weapon system designs.

The Laboratory is currently applying the results of this report and the expertise acquired during this effort to advanced gunship programs. We have provided support to ASD for both the Replacement Gunship Program and the Gunship III effort. An in-house Laboratory research effort is continuing to refine the methodology used in this effort. A major goal at present is to transition this capability to weapon system program managers.

ACKNOWLEDGEMENTS

In conducting the present effort, a number of organizations and individuals provided much needed support and encouragement. Without this support, including the release of required data, our objectives could not have been realized, let alone realized within the time limitations of the effort. One of the particular strengths of this project was the extensive use made of current field data and the extent of user involvement. Extremely generous support was provided from several offices and individuals at the 1st Special Operations Wing (SOW), Hurlburt Field, Florida. Our particular thanks are extended to Lt Col David Sims, Lt Col Walter Evans, and the many crew members of the 16th Special Operations Squadron who gave so freely of their time and experience. Lt Col George Haldane, Chief Master Sergeants Ronald Maloyed and Richard Tusia of the 1st SOW Deputy Commander for Maintenance (DCM) complex provided us with critical guidance and much-needed data during the project. Major Jim Johnson, 2nd Air Division/XP, and Capt Keith Traster, SNOTEC, assisted us greatly in both coordinating visits to Hurlburt Field and obtaining needed data.

Finally, within the Logistics Systems Branch (AFHRL/LRL), certain personnel warrant special mention for their contributions to the project: Major Joseph Nerad, for positive guidance throughout the effort; Mrs. Connie Thompson, for typing, editing, and other "behind-the-scenes" jobs; and, in particular, my co-author, Capt Bill Weaver, who built and exercised the LCOM models, for his significant contributions to all phases of this effort.

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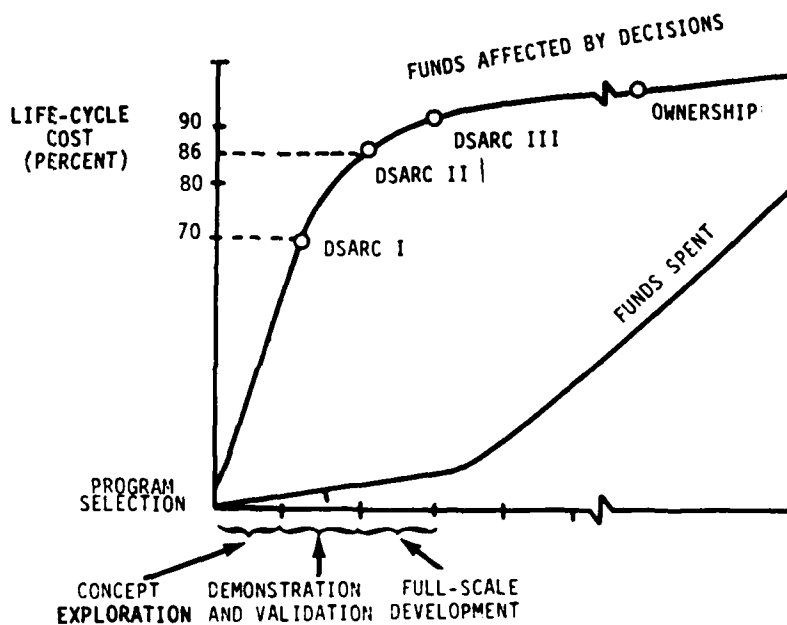
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LOGISTICS COMPOSITE MODEL ANALYSIS OF A FUTURE GUNSHIP DESIGN

I. INTRODUCTION

Background

Designing a modern weapon system is a complex and very time-consuming process. Very little of the actual design process is automated. The designer must consider performance, cost, schedule, reliability, and maintainability requirements co-equally when creating a design. Reliability and maintainability (R&M) requirements have only recently been elevated to this level of importance by the USAF R&M 2000 Action Plan. Although expenditures early in a weapon system program are at a relatively low level, Figure 1 shows that decisions made early in a program lock in most of the life-cycle cost of that program.



SOURCE: DEFENSE SYSTEMS MANAGEMENT COLLEGE

Figure 1. Defense Systems Acquisition Review Council (DSARC) Milestones and Impact on Life-Cycle Cost (LCC).

Decisions affecting 70% of the life-cycle cost are made by the end of concept exploration, and decisions affecting 85% of the life-cycle cost are made before full-scale engineering development begins. The earlier the R&M requirements on a program are established, the greater the impact the requirements can have on program planning and ultimately on the life-cycle cost of the weapon system. Clearly, the importance of analysis during the design phase cannot be overemphasized.

Once a conceptual design exists, it must be evaluated to assess how well it satisfies the design requirements. Current techniques to analyze a conceptual design for R&M are inadequate. Reliability is fairly well understood, and techniques exist to predict system reliabilities, but attempts to link these to some measure of war-fighting capability are difficult. The measures of maintainability are not well understood, and very few techniques exist to analyze the maintainability of a conceptual design.

In anticipation of a replacement gunship development program, the Directorate of Mission Analysis of the Aeronautical Systems Division (ASD/XRM) asked the Logistics and Human Factors Division of the Air Force Human Resources Laboratory (AFHRL/LR) to perform logistics and human factors analyses on the design of a future gunship. The Laboratory recognized this as an opportunity to develop an Air Force in-house capability to respond quickly to requests for evaluations of logistics and human factors impacts of alternative weapon system configurations in the conceptual design phase.

This report is one of six resulting from this research and development (R&D) effort. It documents the methodology and results of an in-house (AFHRL/LRL) Logistics Composite (LCOM) model development effort and assessment of selected logistics requirements. Appendix A contains an overview of the LCOM model. This R&D effort was defined to complement a parallel, contractor-performed effort to quantify logistics resources for a near-term replacement gunship, which is documented in AFHRL-TR-86-21 (Dunleavy, Stephenson, & Ness, 1986).

Scope

The primary purpose of this effort was to develop and demonstrate the capability to respond quickly to requests for evaluations of the logistics impacts of alternative weapon system configurations while still in the conceptual design phase. A second purpose of this LCOM assessment was to analyze specific logistics requirements that could be modeled more accurately using simulation rather than the analytical techniques used by the contractor and documented in the previously mentioned technical report. Thus, the R&D was both a capability development opportunity for AFHRL/LR and an effort to provide data and models needed as input to the proposed Replacement Gunship Program.

II. OBJECTIVES

The R&D objectives of this effort were to develop the LCOM models and quantify the sortie generation capability and maintenance manpower requirements for a 30-day employment of 10 improved AC-130H gunships. The major constraint imposed on this effort was time. The entire project was to last approximately 4 months. The LCOM model scenario requirements were appropriately constrained to be manageable within this timeframe (Section III). The approach taken was to collect the required R&M data (Section IV), create an LCOM model of the baseline AC-130H, and then modify this model to represent a hypothetically improved gunship called the SOF-130 (Section V). This was accomplished for each of two scenarios. The models were then exercised to assess sortie generation capability and maintenance manpower requirements (Section VI).

III. ASSUMPTIONS

The assumptions made in the process of performing this R&D fall into three distinct categories:

1. assumptions about the mission and scenarios,
2. assumptions about the weapon system,
3. assumptions made in the modeling and analysis phases.

This section addresses the first two sets of assumptions. The other assumptions are noted where applicable. Every attempt was made to use the same mission, scenarios, and weapon system as those used in the contractor effort referenced in Section I of this report. Appendix B shows these assumptions translated as an LCOM model scenario.

Mission

Two independent deployments were considered to provide a broader information baseline for the Replacement Gunship Program referenced in the introduction of this report. In the model scenario, 10 gunships (improved AC-130H) would deploy for a 30-day contingency period to either a main operating base (Scenario I) or a forward operating location (Scenario II). Assumed distances from home station to each operating base, within each scenario, were as shown in Figure 2.

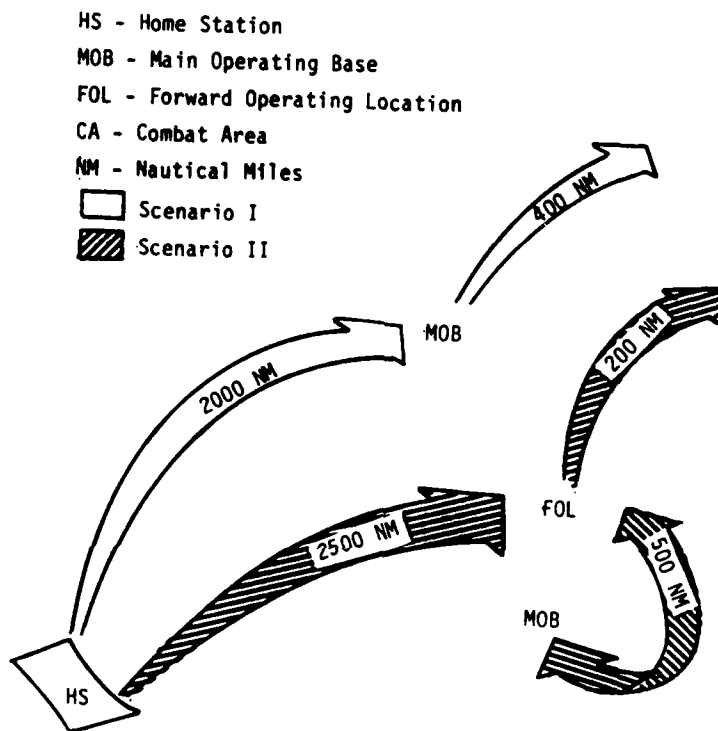


Figure 2. Operating Distances.

The following set of mission-related assumptions were made for both scenarios:

1. Only the employment phase was to be addressed in this effort.
2. Each possessed aircraft was assumed to be available and to fly one sortie on each day of the 30-day contingency.
3. On each of the 10th and 20th days of the contingency, one aircraft was attrited. Furthermore, it was assumed that these attrited aircraft would not be available for cannibalization of spare parts; that is, the aircraft was lost to the unit.
4. Cannibalization of spare parts was not considered.
5. Aircraft were to be launched en masse in a 2.5-hour block with an 8.5-hour average sortie length.

Beyond the general mission-related assumptions discussed above, certain others were made for each scenario.

Scenario I - Operations from an MOB

In this scenario, the 10 gunships were to deploy to, and operate from, a main operating base (MOB) located 400 nautical miles (nm) from the combat area (see Figure 2).

Specific assumptions were:

1. All required aircraft and support resources were in place at the MOB at the start of the 30-day contingency.
2. The MOB had full on- (remove and replace) and off-equipment (intermediate shop) repair capability. Base Level Self-Sufficiency Spares (BLSS) kits were used to provide spare parts for remove, replace, and repair maintenance.
3. The MOB also had the additional capability to perform off-equipment repair for one forward operating location (FOL) using parts from a modified BLSS excluding Wartime Readiness Spares Kit (WRSK) components deployed to the FOL.

Scenario II - Operations from an FOL

In this scenario, which was independent of Scenario I, 10 gunships were deployed to, and operated from, an FOL. This FOL was 500 nm in one direction from a supporting MOB, and 200 nm in the opposite direction from the combat area (see Figure 2). The MOB provided the FOL with intermediate shop repair capability (as noted above). The FOL would only have remove and replace repair capability using parts from the WRSK.

Weapon System

Given the objectives of the present effort, it was necessary to define an improved AC-130H gunship. However, this improved gunship is conceived of as (a) only hypothetical, and (b) only as a prerequisite for this effort's logistics analysis; this configuration is not proposed as a system for future program consideration. For this effort a representative, but hypothetical, 1985-technology AC-130H gunship, hereafter referred to as the SOF-130, was defined such that baseline logistics requirements could be determined for a gunship approaching the late-1980s state-of-the-art technology. Using this methodology, it was concluded that very useful data points could be provided for future evaluations of potential logistics impacts of improvements to the current gunship. However, the present effort is not to be interpreted as such an evaluation. Such a comparison, while capable of being undertaken as an extension of the present effort, would require a more refined set of objectives and an in-depth statistical application of the research methods used. It would also require incorporation of selected recommendations from this report.

Airframe

The platform used for the hypothetical improved gunship was the current AC-130H airframe, due to the ready availability of historical R&M data which could be audited.

Mission Equipment

The mission equipment used for the improved gunship was the existing AC-130H weapon/sensor suite with selected improvements. The final configuration was defined from the ongoing Air

Force/Lockheed Special Operations Forces (SOF) Improvement Package program and the Lockheed Corporation proposed configuration for a replacement gunship. Every attempt was made in this effort to use the same mission equipment configuration used in the contractor-performed logistics requirements study referenced in the introduction of this report. An exhaustive description of the baseline configuration exists there and will not be duplicated here.

IV. DATA BASE DEVELOPMENT

A data base consisting of system R&M data is required to develop an LCOM model. Those critical data include:

1. Failures/sortie/work unit coded item.
2. Mean time to repair, crew complement, Air Force Specialty Code (AFSC), required support equipment.
3. Type of maintenance action.
4. Part designation and consumption.

Maintainability requirements for the current AC-130H were obtained through on-site interviews and observations of maintenance personnel at Hurlburt Field, Florida and direct extractions from the Headquarters Military Airlift Command (HQ MAC) C-130 LCOM model. Appendix C describes in detail this collection and audit procedure. System reliability data on the airframe and that existing mission equipment which remained in the improved weapon system configuration was obtained from AC-130H maintenance data collection (MDC) systems. Appendix C also details this data collection process.

It is generally understood that MDC data are not complete. Some data either are not entered into the system or are not entered correctly. In this case, HQ MAC had performed an audit of their AC-130H MDC system by comparing the AC-130H aircraft maintenance forms with the associated MDC data. The net result showed a need to increase the value for minor maintenance failures by 45%. The system reliability data were then adjusted to reflect this. Two subsystems, electronic countermeasures (ECM) and guns, were also adjusted to estimated wartime usage and failure rates. These adjustments are also discussed in more detail in Appendix C.

After the baseline model data were collected, system reliability data for the improved mission equipment were obtained from the Lockheed Corporation. This was done to remain consistent with the parallel contractor effort referenced in the introduction to this report. These reliability data were compiled from a variety of sources. Some were historical but the preponderance were from vendor data and engineering estimates.

The AC-130H system-level reliability data were then compared to MAC's C-130H LCOM model data base and worldwide data (1962 - 1976) from an AFHRL Historical Analysis of C-130 Resources (Table 1). Minimal differences were found in the reliability between common AC-130H and C-130H systems. This was considered a validation of the data base. Two data bases were then actually created: one representing the current AC-130H and one for the improved SOF-130.

V. MODEL DEVELOPMENT

During this phase, an existing LCOM model was selected and successfully modified to incorporate the developed AC-130H data base and previously mentioned mission/scenario constraints. Appendix D discusses the details of that selection process and the attributes of the selected model. The majority of time spent in the model developmental phase was devoted to modifying the R&M requirements in the selected model to reflect the AC-130H model data. Reliability modifications involved using data extracted from the adjusted AC-130H data for:

Table 1. Failures/Flying Hour Comparison

Systems	MUC	Hurlburt AC-130H	AFMRL C-130E	MAC C-130H	Primary AC/C-130 differences from C-130
Air Frame	11000	.348	.330	.334	Armor Plate, Gun and Sensor Ports and Covers, Infrared Shield
Cockpit and Fuselage	12000	.141	.135	.156	Extra Furnishings and Electronics Racks
Landing Gear	13000	.131	.126	.148	
Flight Controls	14000	.104	.099	.103	ECM Pylon
Turbo Propeller Power Plant	22000	.237	.245	.273	
Auxiliary Power Plant	24000	.024	.021	.033	
Hydraulic Propeller	32000	.092	.088	.090	
Air Conditioning Pressurization	41000	.067	.067	.122	Added duct and valving for Weapon Station/Not Pressurized
Electrical Power	42000	.058	.031	.052	Added Wiring, Search Light
Lighting	44000	.106	.102	.093	Added Lighting for Weapon Suite and Loading
Pneudraulics	45000	.101	.077	.115	Gun Pneudraulics
Fuel	46000	.152	.064	.142	Inflight Refueling System
Oxygen	47000	.013	.012	.025	
Utilities	49000	.028	.023	.042	
Instruments	51000	.073	.070	.049	Added Instrumentation for Weapon Control Operation
Autopilot	52000	.063	.036	.041	
Malfunction Analysis	55000	*	.001	.002	
HF Communication	61000	.027	.006	.019	
VHF Communication	62000	**	.004	.007	
UHF Communication	63000	.031	.015	.016	
Interphone	64000	.106	.017	.047	Interphones to Weapons Stations
IFF	65000	.011	.015	.012	
Emergency Communication	66000	***	.006	.003	
Miscellaneous Communication	69000	.014	.018	.004	
Radio Navigation	71000	.018	.045	.047	Numerous Added Systems, Some Impact by SOF
Radar Navigation	72000	.141	.064	.158****	Numerous Added Systems, Major Impact by SOF
Fire Control	74000	.164	--	--	AC Unique System
Weapon Delivery	75000	.163	--	--	AC Unique System
ECM	76000	.097	--	--	AC Unique System
Photo Reconnaissance	77000	.226	--	--	AC Unique System
Emergency Equipment	91000	-	0	.010	Too few failures to model
Total		2.758	1.717	2.143	

Note. .67 Failures are unique to AC-130 systems; AC Sys Adj would be 2.086 excluding those systems.

*Added to 52000.

**Added to 61000.

***Added to 65000.

****Includes Adverse Weather Aerial Delivery System.

1. modifying system-level failure rates,
2. determining type repair probabilities,
3. determining part consumption rates.

Maintainability requirements consist of maintenance tasks and their associated task times and crew complements. Modifications to the maintainability requirements of the selected airlift model included:

1. reflecting the full Air Force Specialty Code (AFSC) structure,
2. adding the capability to model troubleshooting and verifying tasks,
3. consolidating networks to the two-digit work unit code (WUC) level,
4. modifying task times and sequences and crew complements.

Two important assumptions were made here:

1. no cross-utilization or assist task qualifications of AFSCs were used.
2. shift structure was to be three shifts, 8 hours per day, with a manhour allowance factor of 309 manhours per person per month ("surge" environment).

The initial LCOM model developed simulated operations from an MOB to allow installation of full networks for remove, replace, and repair maintenance capability. A network switch was then installed to delete the MOB intermediate shop repair capability for FOL (remove and replace maintenance only) assessment.

The MOB LCOM model was validated by comparison of simulation results with results from MAC's existing C-130H LCOM model. Manhour demands, flying hours, and pre- and post-mission processing times all compared favorably. Table 2 shows that comparison in terms of direct productive manhours per AFSC for each model. Note that when unique systems are excluded, both models produce very similar direct productive manhour requirements. The MAC LCOM was modeled on 32 aircraft versus 10 aircraft in this model. The MAC LCOM manhours in Table 2 were adjusted by a factor of 10/32 for this comparison. This completed the LCOM model for the current (or baseline) AC-130H, which is referred to as the AC model. The next step was to create the improved gunship (SOF-130) LCOM model, hereafter referred to as the SOF model.

Creation of the SOF model required modifying the AC model to the same configuration as the improved gunship referenced in Section III of this report. This entailed incorporating the improved systems and reliabilities into the baseline AC-130H LCOM model. Maintainability requirements (task times/crew complements) for the improved systems could not be revised, however, since no data on these were available. The performance of a comparability analysis to obtain these data was beyond the scope of this effort. Because the model was compressed to the two-digit WUC or subsystem level, a reasonable substitute was to use the current maintainability data consolidated to the subsystem level. This provided a worst-case estimate where the improved equipment was considered to be no more maintainable than current equipment. This affects the interpretation of the results and is discussed again later in this report.

Table 3 shows the differences between the baseline and the improved gunship models in terms of mean flying hours between maintenance actions. This comparison showed a reasonable amount of improvement where expected, providing confidence in the models. Since both the baseline AC and improved SOF gunship LCOM models had on/off-equipment-repair switches, the four models required for the analysis phase were completed.

Table 2. AC/C-130 LCOM Direct Productive Manhours Required

AFSC	AFMRL AC-130H	MAC C-130H	Comments
321X2	1,205	***	Unique AC Equip Support (Weapons Guide)
322X2	665	***	Unique AC Equip Support (SENSORS)
325X1	616	782	
328X0	2,190	2,272	
328X3	936	***	Unique AC Equip Support (Avionics)
328X4	656	295	Unique AC Equip Support (Avionics)
404X1	529	***	Unique AC Equip Support (Guns)
423X0	1,726	1,994	
423X1	662	680	
423X3	1,249	1,990	AC Wings Mod and Fewer Aircraft Flying Longer Sorties
423X4	748	984	Fewer Aircraft Flying Longer Sortie Lengths
426X3	4,429	3,685	Heavier Takeoff Wts, Jet AFSC Used On All Eng Runs
427X0	133	76	Gun Machining and Repair
427X1	83	**	
427X2	10	**	
427X3	23	**	
427X4	39	17	Gun Heat Treating
427X5	1,535	1,045	Gun Ports and IR Screens
431X3	4,817	6,913	(Work Differentiation Between Flt Line and Aero Repair
431R3	2,061	858	Personnel and MAC LCOM C-130 Multi Location Support)
462X0	2,717	---	Unique System Support (Munitions)
431I3	**	643*	
Total	27,029	21,791	(6,413 Hours of Difference Attributed to Unique System Support for AC-130H)

*Not required wartime.

**Not simulated.

***No requirement.

VI. ANALYSES AND FINDINGS

In this phase, the models were used to address the analytic objectives of this effort: first, determine if the required sortie generation capability could be attained; second, determine the minimum maintenance manpower required, by AFSC and shift, to support those sorties.

Sortie Generation Capability

The first objective, the capability of the airframe to achieve the desired sortie rate, was a prerequisite to achieving the second objective, since there would be no reason to establish maintenance manning levels to support unflown sorties. This was accomplished by running the models, with unlimited manpower and spare parts, at a higher sortie rate than the target sortie rate. There was genuine concern that the aircraft might not achieve the target sortie rate of one sortie/aircraft/day because of the extreme demands of the assumed mass launch scenario. Table 4 shows the results of the initial unconstrained run of the model simulating the improved AC-130H (SOF-130) in Scenario I (MOB). Note that the SOF-130 aircraft barely exceeded (284) the target sortie rate (270) with attrition considered. This flying scenario was obviously highly taxing and allowed very little time for turning aircraft and backordering tasks and required resources. This was evident in the relatively high manpower requirements and low manpower utilization rates observed in subsequent simulation runs.

Table 3. Failures/Flying Hour AC-130H/SOF-130 Comparison

Systems	WUC	AC-130 LCOM	SOF-130 LCOM
Air Frame	11000	.348	.348
Cockpit and Fuselage	12000	.141	.141
Landing Gear	13000	.131	.131
Flight Controls	14000	.104	.104
Turbo Propeller Power Plant	22000	.237	.237
Auxiliary Power Plant	24000	.024	.024
Hydraulic Propeller	32000	.092	.092
Air Conditioning Pressurization	41000	.067	.067
Electrical Power	42000	.058	.058
Lighting	44000	.108	.108
Pneudraulics	45000	.101	.101
Fuel	46000	.152	.152
Oxygen	47000	.013	.013
Utilities	49000	.028	.028
Instruments	51000	.073	.073
Autopilot	52000	.063	.063
Malfunction Analysis	55000	*	*
HF Communication	61000	.027	.027
VHF Communication	62000	**	**
UMF Communication	63000	.031	.031
Interphone	64000	.106	.106
IFF	65000	.011	.011
Emergency Communication	66000	***	***
Miscellaneous Communication	69000	.014	.014
Radio Navigation	<u>71000</u>	.018	.003
Radar Navigation	<u>72000</u>	.141	.082
Fire Control	<u>74000</u>	.184	.122
Weapon Delivery	<u>75000</u>	.163	.163
ECM	<u>76000</u>	.097	.102
Photo Reconnaissance	<u>77000</u>	.226	.061
Emergency Equipment	<u>91000</u>	--	--
Total		<u>2.758</u>	<u>2.462</u>

*Added to 52000.

**Added to 61000.

***Added to 65000.

Impacted system.

Maintenance Manpower Requirements

The next objective, determination of maintenance manpower requirements, was a two-step process. First, the minimum position manning requirements for each AFSC were determined. Secondly, those positions had to be converted into actual manpower requirements. This was accomplished for both aircraft models and scenarios.

Table 4. Unconstrained SOF-130 MOB Results

	Results
<u>MISSIONS</u>	
Number of Missions Requested	325.00
Number Accomplished	284.00
Percent Accomplished	87.38
Average Aircraft Post-Sortie Time (hours)	6.75
Number of Post-Sorties Completed	284.00
<u>AIRCRAFT</u>	
Number of Aircraft Auth (EOP)	10.00
Number of Aircraft-Days Avail	300.00
Percent Sorties (Incl Alert)	34.11
Percent Unscheduled Maintenance	25.35
Percent Scheduled Maintenance	13.20
Percent Not Mission Capable Supply (NMCS)	0
Percent Mission Wait Status	4.82
Percent Service + Waiting	00
Percent Operationally Ready	22.09
Average Aircraft Post-Sortie Time (Hours)	6.33
Average Number of Sorties/Aircraft/Day	.97
Flying Hours	2486.49
Average Aircraft Pre-Sortie Time (Hours)	3.22

Position Manning Requirements

The determination of LCOM position manning requirements was interactive. First, FOL position manning requirements for each AFSC were constrained (manning levels were lowered until the sortie generation rate degraded to the target sortie rate), with spare parts unconstrained. Secondly, the off-equipment switch was turned on, manning was unconstrained, and spares were constrained (reduced) until the sortie generation rate began to fall. This caused a demand for off-equipment repair capability at the supporting MOB, allowing constraint of back shop manning to impact the sortie rate. The final step was to constrain the MOB position manning levels. This process was accomplished for both the AC-130 and the SOF-130 models. A complete listing of position manning requirements for each aircraft and scenario by AFSC and shift is shown in Appendix E.

Actual Manpower Requirements

The second step, determination of manpower requirements from the position manning levels, required further analysis due to extremely low shift utilization of the manning caused by the peak demand of the mass launch scenario, and the requirement to convert the positional manning to whole manpower spaces. Appendix F shows a sample output from a computerized allocation routine used to facilitate this analysis and perform the manpower conversion. This was accomplished for each AFSC by shift. Manpower was computed only if the shift's manhour need was greater than 20 hours/month. Requirements less than this were added to one of the other shifts as on-call transferable work since all AFSCs had low utilization rates.

Figure 3 shows the resulting maintenance manpower requirements. The most obvious result is the very small decrease (approximately 5%) in maintenance manpower required by the improved gunship. This is not intuitively obvious when the reliability (expressed as mean time between failures (MTBF)) has improved by a factor of from 2 to 10 times, albeit on a limited amount of equipment. This is due primarily to the requirement to have maintenance personnel available to fix the aircraft when it breaks, even if it does not break very often. What is primarily affected in this situation is the utilization of that manpower. This, in turn, becomes driven by other factors such as mission, scenario, and maintenance concept.

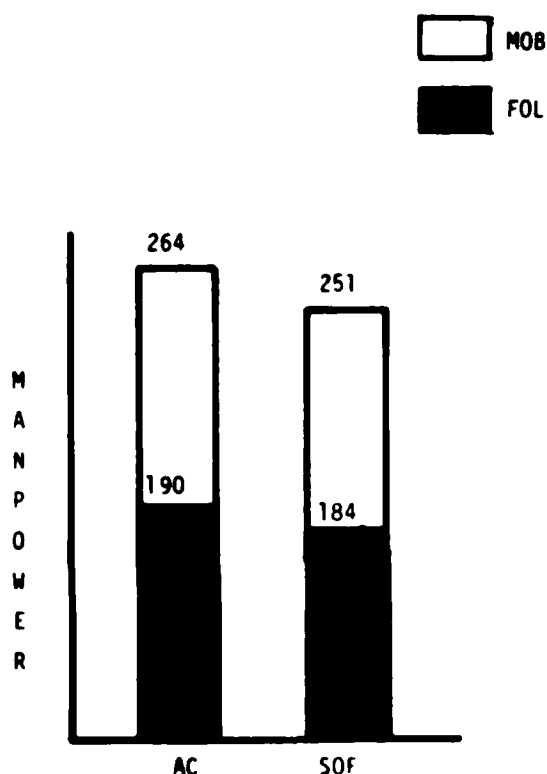


Figure 3. Maintenance Manpower Requirements.

This combination of low numbers of personnel in some AFSCs and low utilization rates in most AFSCs implies that further reductions in maintenance manpower could be attained. Although not specifically addressed in this effort, cross-utilization and consolidation of AFSCs would appear to provide significant further reductions in maintenance manpower requirements.

Appendices G and H show the result of the LCOM assessments in terms of impact on manpower needs of the improved mission equipment reliabilities, and a comparison to the previously mentioned contractor study. Note in Appendix H that although the two studies produced the same required total manpower, the LCOM analysis showed considerable differences in the AFSC mix. This was caused by the high fidelity of the LCOM model in comparison to the audit methodology used to acquire the contractor estimate of manpower.

VII. SUMMARY

Conclusions

The primary conclusion is that quantitatively oriented front-end logistics analysis is possible and that this has been a successful demonstration of this Air Force capability. We

believe this is the first time that LCOM models have been used to analyze a design in the conceptual phase. The research objectives of quantifying the sortie generation capability and maintenance manpower requirements were achieved. The lack of maintainability data for certain improved systems on the SOF-130 requires further discussion of the results.

The intended purpose of this analysis was a comparison of the maintenance manpower requirements of the baseline AC-130H versus those of the improved SOF-130. The lack of maintainability data for the improved systems on the SOF-130 necessitated the use of maintainability data from comparable systems on the current AC-130H gunship. The use of the same maintainability data for each aircraft changes the interpretation of the results. By essentially holding maintainability factors constant, the only variable is reliability. Thus, the analysis quantifies the impact of changes in hardware reliability on maintenance manpower requirements. It cannot be assumed that the resulting manpower level is representative of what would actually be required for that fielded aircraft (all other parameters remaining constant).

A simple example illustrates this concept. Imagine that a certain piece of equipment on the baseline aircraft had a 100-hour MTBF rate and a 3-hour mean time to repair (MTTR). The corresponding equipment on the improved aircraft has a 1,000-hour MTBF rate but, because of the nonavailability of maintenance data on this new piece of equipment, must be assumed to also have a 3-hour MTTR. Thus, this new equipment will fail only one-tenth as often as the part it replaces, but will still require the same amount of time to repair. Even in this situation, with improved reliability and constant maintainability, a manpower reduction would be expected. This was verified by the reduction obtained in this analysis. It is also intuitively obvious that a further decrease in manpower should result if improved maintainability can be included in the model. Our hypothesis is that a further improvement would be obtained. However, we believe that this decrease would be relatively small, on the order of the 5% reduction obtained in this effort.

This leads us to conclude that improvements in equipment reliability alone will not achieve significant reductions in maintenance manpower requirements. They must be made in conjunction with improvements in other supportability factors such as the maintenance concept, specialty consolidation, aircraft basing mode, and other "ilities" (testability, accessibility, etc.). It is the synergistic effect of these individual factors which will provide significant reductions in supportability costs while increasing war-fighting capability.

The short-term value of this effort is to provide data and findings which could be used in the Replacement Gunship Program. The long-term value is the methodology itself, which can be used to evaluate the suitability of conceptual designs to meet future operational needs.

Recommendations

Recommendations are divided into those relevant to near-term and possible long-range gunship programs to provide input for the currently envisioned Replacement Gunship and Gunship III Programs.

Near-Term

The data and findings generated by this R&D effort could be used during the preparation of any future replacement gunship Request for Proposals (RFP).

Once a proposal has been selected, the design could be evaluated for maintenance manpower requirements using the developed LCOM models. This would identify areas of critical program management attention. For example, a new type of sensor may be shown to require a large number

of people to maintain it. This would allow program managers to review the design and support concepts of this equipment to reduce the number of maintenance personnel required.

Again, with a selected design, the feasibility of a true two-level maintenance support concept could be evaluated and the impact of such a concept upon maintenance manpower requirements determined. For example, the tradeoffs between manpower reductions and increased spare parts costs could be examined, along with the resulting sortie generation capability.

Long-Range

The operations, maintenance, and support environments of the year 2000 will undoubtedly differ from those of today. With the leadtime available to any follow-on gunship program, the impacts of these changes should be evaluated and design-to requirements developed for influence in weapon system conceptual design. The key here is the flexibility of the developed LCOM models. Once an aircraft design has been modeled, any number of operations, maintenance, and support concepts can be examined. The resulting maintenance manpower requirements and sortie generation capability could then be determined. Techniques already exist to determine the optimal combination of multiple parameters. For example, response surface methodology could be employed to determine the "optimum" combination of operations, maintenance, and support concepts.

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Dunleavy, A.O., Stephenson, J.B., & Ness, W.G. (1986). Sustained firepower study: Logistics requirements for deployment of an improved AC-130 gunship (AFHRL-TR-86-21, AD-B016 414). Wright-Patterson AFB, OH: Logistics and Human Factors Division, Air Force Human Resources Laboratory.

Simulation software users reference guide (15 April 1981). Randolph AFB, TX: Headquarters, Air Force Management Engineering Analysis.

APPENDIX A: LOGISTICS COMPOSITE (LCOM) MODEL SUMMARY

TYPE MODEL: Logistics Capability

DEVELOPED BY: Rand Corporation

DATE COMPLETED: 1966

CURRENT REVISION: 1983

PRODUCT DIV USE/SYSTEMS USED ON: ASD/F-15, F-16, A-10, F-111, ATF, AFOTEC, TAL, SAC, MAC, AFHRL/LR, contractors.

DOCUMENTATION: Simulation Software Users Reference Guide, 15 Apr 1981, AFR 25-5(Vol 4.), 1 December 1980, and CDC/IBM Users Guide Job Control Language for LCOM, Nov 1981

PROGRAM LANGUAGE: SIMSCRIPT II.5

DESCRIPTION/CHARACTERISTICS: The model simulates airbase logistics support operations. It measures sortie generation capability, aircraft maintenance manpower requirements, and aircraft supportability. It considers the interactions of all support resources (i.e., manpower, spares, support equipment, facilities) and is useful for trade studies and sensitivities of aircraft logistics performance. It provides information on which to base comparisons of sortie generation capability of alternative weapon systems. It is also useful for manpower determination planning and tradeoffs concerning supportability.

REMARKS: Typically a very complex model to run; but as shown in this effort, can be run in a simplified mode. Input contains information on failure rates, resources, tasks, aircraft operations, maintenance policies, mission types, priorities, cancellation policies, and tradeoff times. Data usually extracted from comparable systems early in system development. Outputs include performance statistics on mission success, aircraft availability, manpower usage, supply, shop repair, support equipment, and facilities.

ACCESS PROCEDURE: Available on CDC, Honeywell, and IBM systems.

SPONSOR: Aeronautical Systems Division (ASD/ENSSC)

CONTACT(S): Mr. R. Kronk, ASD/ENSSC, AUTOVON 986-0064

Mr. William Drake, Air Force Maintenance, Supply, and Munitions
Management Engineering Team (AFMSMET), AUTOVON 787-3755

DLSIE REF#: 84/62 (LD 53358M); 84/161 (LD 33938MF)

ASSESSMENT: LCOM provides the best analytical process for modeling the pre-flight and post-flight logistics tasks associated with aircraft missions. It may also be used to model logistics operations for other than aircraft weapon systems or subsystems. However, LCOM is a complex model, and learning to run the model requires a significant amount of time. Also, the actual preparation of input data is a time-consuming operation. For important evaluations or major management decisions, the effort and time required are justified. Significant data base construction software has been developed to convert historical operational base-level maintenance data to unscheduled maintenance network definitions for existing systems. Similar capabilities are lacking for postulated systems.

APPENDIX B: LCOM MODEL SCENARIO

OPERATIONS AND MAINTENANCE SCENARIO DEVELOPMENT:

The operations and maintenance scenario used for this assessment was derived from the assumptions and constraints necessary to assure consistency with a parallel contract effort evaluating other logistics requirements. The following scenario, in AFR 25-8 (rescinded) LCOM scenario format, was developed from the above constraints.

1. GENERAL REQUIREMENTS:

- a. Number and type aircraft: 10PAA AC-130 and 10PAA SOF-130 each will be modeled.
- b. Manpower availability: Manpower availability will be 309 manhours per month (surge manning).
- c. Manpower utilization: The direct utilization rates of each specialty will be the largest percentage obtainable without decreasing the prescribed sortie rate.
- d. Minimum crew complements: Minimum AFSC crew complements will be maintained on at least one shift.
- e. Minimum manpower cutoff: Direct work of 20 manhours per month per shift will be transferred to the following shift as standby transferable work on-call.
- f. Cross-utilization: No cross-utilization or assist task qualifications will be utilized.
- g. Shift structure: Work shift structure will be three shifts per day, 8 hours per shift, where multiple shifts are required.

2. FACILITIES AND DEPLOYMENT:

- a. Number of locations and the primary aircraft authorization (PAA) size at each site:
 1. One Forward Operating Location (FOL) with 10PAA.
 2. One Main Operating Base (MOB) with 10PAA.
- b. Supply provisioning:
 1. FOL will operate from a 30-day Line Replaceable Unit (LRU) War Readiness Spares Kit (WRSK).
 2. MOB will operate from a Base Level Self-Sufficiency Spares (BLSS) kit, with one additional Shop Replaceable Unit (SRU) kit to support SRU repairs for one FOL.
- c. Resupply: Resupply time is in excess of 30 days and thus is not applicable to this effort.
- d. AGE and support equipment: Aerospace ground equipment (AGE), avionics test equipment, and expendables are not considered here.
- e. Maintenance capability at locations:

1. FOL will have remove and replace on-equipment maintenance capability only.
2. MOB will have on- and off-equipment remove replace and repair capability for its own aircraft and off-equipment repair capability for one FOL.
3. Return of repaired assets from the MOB to the FOL will not be modeled.
- f. Cannibalization: Cannibalization will not be considered.
- g. Aircraft capability status: Aircraft will be returned to mission capable status through on-equipment repair or removal and replacement of defective components.

3. MISSION REQUIREMENTS:

- a. Mission types: One mission type was scheduled, with an 8-hour sortie length.
- b. Aircraft type:
 1. AC-130 for baseline MOB and FOL models.
 2. Modified AC-130 (SOF-130) MOB and FOL models.
- c. Probability of expenditure of combat load: 100%.
- d. Alternate configurations: No alternate configurations used.
- e. Alerts: No alert scheduled.
- f. Number of aircraft per mission: Each mission will require a single aircraft.
- g. Recovery point: Recovery will be accomplished at the point of departure.
- h. Air-refueling: Air-refueling will be considered in terms of increased failures in the air-refueling systems.
- i. Mission interval: Missions will be launched within a 2.5-hour block.
- k. Cancel time: Mission cancellation time is 2.0 hours.
- l. Mission peculiar equipment: Extent of operations of mission peculiar equipment will not be considered.

4. OPERATIONS SCHEDULING POLICY:

- a. Weather: No delay or cancellation for weather.
- b. Air aborts: Will not be considered.
- c. Spare aircraft: No spare aircraft.
- d. Aircraft turn rate: Aircraft will be turned as required to meet required sortie rate.
- e. Day and night: No definition between day and night missions.

f. Mission launch window will be:

<u>Simulation hour</u>	<u>% missions scheduled</u>
1	20
2	60
3	17
4-24	1 each

5. GROUND ALERT: None scheduled.

6. FUNCTIONAL CHECKLIST: None will be scheduled.

7. MAINTENANCE CONCEPTS AND ORGANIZATION:

a. Organization structure: AFR 66-1.

b. Integrated avionics repair: Will not be used.

c. Combat quick turns: Will not be applicable.

d. Deferred maintenance: None.

e. Launch support teams: Will not be modeled.

f. Munitions download for maintenance: Will not be modeled.

g. Level of repair modeled: Repairs will be to the system (2-digit work unit code level) at levels indicated in historical data or through engineering estimates for new systems on the SOF-130.

h. Phase, corrosion control, and gun inspections (except daily preflight): Will be deferred.

i. Time change inspections: Will not be considered in the model.

8. COMBAT BATTLE DAMAGE: Combat battle damage will not be considered in the model; however, one each aircraft will be attrited on day 10 and day 20 of the simulation.

APPENDIX C. LCOM MODEL DATA COLLECTION AND AUDIT

1. DATA COLLECTION:

Data collection is described here, for documentation purposes, as if one were beginning the modifications to the selected LCOM model from scratch. AC/SOF-130 users would have a much-abbreviated effort, confined to refining the Reliability and Maintainability (R&M) elements and addressing scenario differences from the test model. In this step of the study process, historical reliability data, associated maintainability requirements, work flow sequencing, and scheduled maintenance requirements are acquired. Additionally, R&M data are acquired on any updated or new systems being incorporated into the SOF updated version of the AC-130. (Data requirements for the common AC/C-130 systems were derived from MAC's C-130 LCOM.) Historical data were collected via message, literature search, or site visit. Audit data were collected via site visit to Hurlburt Field and message with HQ MAC/XPMEM. Engineering data were acquired from the Lockheed Corporation. The data collection process is as follows:

- IDENTIFY THE DATA NEEDS
 - Scenario-Driven
 - Weapon-Specific Systems
- COLLECT HISTORICAL (RELIABILITY) DATA
 - Base MDC Data
 - Maintenance Digests
 - Parts Demand Data
 - Shop Logs
 - Technical Reports
 - Other LCOM Models
- AUDIT (MAINTAINABILITY) DATA
 - Repair Time
 - Crew Complement
 - Task Sequence
 - Access Requirements
 - Scheduled Maintenance Requirements
 - Organizational Structure
 - Shop AFSCs
- DEVELOP ENGINEERING ESTIMATES (NEW SYSTEMS)
 - Removals Per Sortie
 - Comparability Data
 - Repair Time
 - Crew Complement
 - System(s) Replaced

2. THE DATA COLLECTION PROCESS:

a. Identify the data needs:

1. The LCOM scenario provides the constraints that identify what data to collect, from where, on what weapon system, during what timeframe, for what wartime/peacetime conditions

set. For the AC/SOF-130, this required system-level data, on AC/SOF improved 130s, from a base with sufficient historical R&M data on the AC-130, during timeframe 1984, for the defined wartime conditions set (MOB and FOL).

2. The steps used to define data needs for this AC-130 study were:

a. Weapon-specific systems were identified for data collection from the C-130/AC-130 Work Unit Code (WUC) manual acquired from the Air Force Logistics Command (AFLC) technical library.

b. A list of systems being improved on the SOF-130 and the systems being replaced had to be acquired from the contractor to remain consistent with a parallel effort.

c. Hurlburt Field provided R&M data on 10 AC-130Hs as the baseline MOB site.

b. Collect historical reliability data:

1. Maintenance Data Collection (MDC) system data: These data were acquired on the AC-130Hs at Hurlburt Field, Florida, for the CY84 timeframe. The data provided aircraft component failure rates, repair actions, and resources used to make the repair (man, part, machine) during the historical timeframe. The MDC data had to be collected in a digitized form for processing through the Common Data Extraction Program (CDEP), which converts the MDC data to an LCOM readable format. ASD/ENSSC maintains this software locally and has the specifics on formats for acquiring these data.

2. Maintenance digests: These monthly reports provide data on flying hours, sorties, work center codes (these items are needed for the above CDEP processing), and critical component failure information. The digests are maintained at the Deputy Commander for Maintenance (DCM) Analysis Office.

3. Parts demand data: These data are maintained in various HQ AFLC computer data bases (e.g., D029, D056). The data provide parts demand rates on the supply system and WRSK kit parts sizing. Although not used in the AC-130 development, comparison of these data would enhance the validity of a baseline AC-130 model.

4. C-130 technical reports: Technical reports on the reliability of the C-130H systems were acquired through literature searches of the Defense Technical Information Center (DTIC). Data from these reports were used in conjunction with the CDEP results to define and verify reliability requirements of the common C-130/AC-130 systems.

5. Additional comparability data: Additionally, system-level data had to be acquired from HQ MAC/XPMEM to adjust for missing C-130 MDC data. Adjustments for missing MDC data provided by HQ MAC/XPMEM were translated into increased probabilities of minor maintenance. Network failure clocks were then factored in to incorporate the increase in undocumented minor maintenance failures. Also, peacetime and projected wartime equipment/armaments usage data were used to adjust ECM and weapon system reliabilities for wartime conditions. Adjustments for the wartime usage were applied to specific system probabilities and translated back to increased failures or decreased failures at the system level.

6. LCOM models: The CX99 LCOM model was acquired from ASD/ENSSC in computer form. That model was resident on the ASD NAS 7000 system and had been thoroughly debugged. It was the model selected for use in the AC-130 assessment. The C-130 LCOM model was acquired in both computer and hard copy from HQ MAC/XPMEL to explore conversion of a full-size model to one adequate for this effort. This unsuccessful attempt is documented in Appendix D. It was later

used as a source of repair time/resource requirements for the common C-130/AC-130 components and to verify that the modified model was producing accurate manpower results.

7. Shop logs: Logs were acquired during an on-site audit of the AC-130H maintenance units at Hurlburt Field, Florida. Information from these logs was used to identify part repair work sequencing and scheduled inspection requirements that may have biased the MDC data. Additionally, the logs provided direct reliability data on gun systems under repair and ECM shop repair actions.

c. Audit maintainability data: These audits collected AC-130H peculiar data for on- and off-equipment repair times, crew complements, task sequencing, and access needs. The audits determined:

1. Organization and shop AFSCs: The initial contact was made with the DCM to determine the maintenance organization structure, shop responsibilities, and AFSCs.

2. Scheduled maintenance: The Organizational Maintenance and Munitions Maintenance squadrons were audited to determine scheduled maintenance task requirements for aircraft configuration, weapons loading, launch, recovery, and scheduled pre- and post-flight inspections.

3. Unscheduled maintenance: The following additional audits were conducted and data collected to determine unscheduled maintenance requirements.

a. The lists of the common and unique C-130/AC-130 systems developed from the WUC manual were reviewed, verified, and updated by maintenance technicians from the maintenance shop responsible for each system.

b. Systems access tasks unique to the AC-130H (e.g., removal of armor plate) were identified.

c. Those tasks unique to the AC-130H systems were audited to determine repair time, crew complement, task sequencing, and testing requirements. These audits were accomplished at the LRU level of detail and then compressed using weighted averaging techniques to arrive at the system-level tasks used in the model.

d. Task data for the common AC/C-130 systems were then extracted from HQ MAC's C-130 LCOM model and compressed in a similar manner to fill in the R&M requirements for the common AC/C-130 systems.

d. Develop engineering estimates by acquiring R&M data on SOF-130 improved systems: As mentioned earlier, the SOF improvement package contractor (Lockheed Corp) provided engineering estimates on the SOF systems improvements. The estimates were for only the number of off-shelf demands and thus, did not provide information concerning on-aircraft nonremoval maintenance or cannot duplicate (CND) maintenance. Additionally, estimates on maintainability elements were not available. Thus, for the test models developed here, a factor was developed by dividing the historical removal rate by the projected demand rate. That factor was then used to adjust all task reliabilities. No change was made to the maintainability requirements for the SOF model.

APPENDIX D: LCOM MODEL SELECTION

The lack of an existing AC-130 LCOM model, combined with time and manpower limitations, focused selection efforts on finding an existing LCOM model which could be suitably modified. Three models were reviewed: the C-130, C-141, and ASD's generic CX airlift model. The first two models were full-detail LCOM models which experimentation showed would require a large amount of time to compress and modify. Additionally, these two large models suffered from long run times (2 to 4 hours) and lack of documentation, hindering, if not making impossible, the modification and compression tasks. The last model, the CX, was the only model that appeared singularly suited for modeling needs. The generic CX airlift model was thus selected for this effort.

The CX LCOM model was a compressed generic representation of MAC's C-141 LCOM model. The CX model was available on the ASD computer system and ran rather quickly because of its compression to the two-digit work unit code level, which corresponded to the level of detail required in this effort. Execution time of the model ranged from 2 to 10 minutes, depending on the detail required in the post-processor reports. The primary shortfalls of the CX LCOM model were that it contained generic compressed AFSCs which had to be expanded, and the RAM measures (now C-141) had to be changed to reflect those for the AC-130H. Networks also had to be added to represent troubleshooting, removal for other maintenance, and cannot duplicate maintenance tasks. The C-130 LCOM model was used to provide some of these maintainability data. Specific data on task duration, crew complement, and AFSC requirements were derived for the common C-130/AC-130 systems and included in the modifications to the CX. This significantly decreased the time to acquire maintainability data. The data collection and specific modifications to correct these deficiencies accounted for much of the model development time. This level of effort would not have to be repeated for future assessments of the AC-130/SOF-130, but is mentioned here in case users wish to address other airframes.

APPENDIX B: POSITION MANNING REQUIREMENTS

AC-130

SOF-130

AFSC	SHIFT A			SHIFT B			SHIFT C			SHIFT A			SHIFT B			SHIFT C		
	ON	OFF	UTE	ON	OFF	UTE	ON	OFF	UTE	ON	OFF	UTE	ON	OFF	UTE	ON	OFF	UTE
321X3	2	0		3	2		3	2		2	0		3	2		3	1	
	.14	0		.55	.67		.43	.65		.13	0		.47	.48		.41		
Adj Req	3/.14	0		4/.51	3/.56		3/.54	3/.55		2/.16	0		3/.58	2/.60		3/.51	2/.47	
322X2	1*	0		2	2		2	1		1*	0		1*	2		2**	0	
	.19	0		.39	.78		.36	.75		.14	0		.30	.53		.26	0	
325X1	2*	0		3	2		2**	1		2**	0		3	2		2	0	
	.05	0		.42	.55		.28	.64		.05	0		.45	.63		.28	0	
328X0	2	0		10	4		4	3		3*	0		10	3		4	3	
	.09	0		.52	.64		.35	.76		.07	0		.52	.67		.31	.77	
328X1	2**	0		3	1		2	1		0*	0		2	1		2**	1	
	.05	0		.45	.67		.40	.71		0	0		.36	.42		.14	.64	
328X3	2**	0		4	2		2	2		2	0		4	2		2	2	
	.05	0		.44	.62		.41	.77		.05	0		.41	.51		.34	.81	
Adj Req	2/.10	0		7/.52	4/.64		3/.56	4/.79		2/.10	0		7/.48	3/.70		3/.46	4/.83	
328X4	0*	0		4	1		2	0		0*	0		3	1		2**	0	
	0	0		.46	.41		.34	0		0	0		.38	.24		.13	0	
404X1	0*	0		2**	2		2**	2		0	0		2**	1		0*	0	
	0	0		.32	.56		.11	.73		0	0		.15	.62		0	0	
423X0	2**	0		6	3		4	3		4	0		6	4		4	3	
	.09	0		.33	.77		.41	.77		.08	0		.49	.73		.45	.82	
423X1	2**	0		4	3		2	0		0*	0		4	2		2	0	
	.08	0		.43	.66		.36	0		0	0		.44	.62		.39	0	
423X3	2*	0		4	3		2	2		2*	0		4	3		2	2	
	.12	0		.54	.61		.52	.54		.08	0		.53	.78		.55	.57	

APPENDIX E: POSITION MANNING REQUIREMENTS (Continued)

AC 130

SOF-130

AFSC	SHIFT A			SHIFT B			SHIFT C			SHIFT A			SHIFT B			SHIFT C		
	ON	OFF	UTE	ON	OFF	UTE	ON	OFF	UTE	ON	OFF	UTE	ON	OFF	UTE	ON	OFF	UTE
423X4	0	0	0	4	1	1	2**	2	.45	0*	0	0	4	1	1	2**	2	.59
	0	0	0	.45	.82		.24	.45		0	0	0	.40	.77		.24	.59	
426X3	5	7		13	6	6	6	8		5*	7	13	6	6	6	6	8	
	.10	.57		.49	.69	.44	.44	.59		.07	.80	.50	.77		.43	.79		
427X0	0	0	0	2**	0	1	0	0		0	0	2**	0	0	0*	0	0	
	0	0	0	.23	0	.11	0	0		0	0	.27	0	0	0	0	0	
427X1	0	0	0	2**	0	0	0	0		0	0	2**	0	0	0	0	0	
	0	0	0	.13	0	0	0	0		0	0	.10	0	0	0	0	0	
427X3	0	0	0	1**	0	0	0	0		0	0	1*	0	0	0	0	0	
	0	0	0	.04	0	0	0	0		0	0	.04	0	0	0	0	0	
427X5	0*			2	6	2	2	5		0	0	2	7	2**	2**	5		
	0			.44	.75	.26	.76			0	0	.45	.76		.19	.74		
431X3	10			12	0	24	0	0		10	0	12	0	24	0	0		
	.24			.67	0	.38	0	0		.20	0	.60	0	.38	0	0		
431R3	2*			10	0	4	0	0		2	0	10	0	4	0	0		
	.05			.59	0	.49	0	0		.16	0	.65	0	.53	0	0		
462X0	0	0	0	8	4	4	6	6		2	0	8	4	4	6	6		
	0	0	0	.53	.79	.45	.76			.20	0	.48	.81	.44	73			
Adj Req	0	0	0	15/.51	8/.72	7/.47	11/.75	3/.24		0	0	14/.51	8/.74	6/.54	10/.80			
462L0	4	0	0	2	0	2	0	0		4	0	2	0	2	0	0		
	.12	0	0	.59	0	.26	0	0		.09	0	.58	0	.31	0	0		

* MAX Crew Demand is 2 or 3 but will fill from next shift on-call due to low demand and backorder.

** MAX Crew is 2 or 3, Min manning must be =2 or 3.

APPENDIX F: POSITIONAL TO WHOLE MANPOWER CONVERSION

LOCATION: AAA TYPE: MOB MAF: 305
 FAC: 2410 AFSC: 1 PSR UTE: 0.22659375
 CUMULATIVE UTE: 0.4557188047
 SHIFT A PSR POS: 2 CONSTRAINT: DIRECT PRODUCTIVE UTE= 0.0723020931
 SHIFT B PSR POS: 6 CONSTRAINT: DIRECT PRODUCTIVE UTE= 0.38559375
 SHIFT C PSR POS: 4 CONSTRAINT: DIRECT PRODUCTIVE UTE= 0.2728229159
 A. TOTAL SIMULATED MANPOWER: 2
 B. AVAILABLE MHRS/MONTH IN SIM. (SEE NOTES) 2922.24
 C. MANPOWER REQUIRED (B/MAF): 9.45708437
 D. ADJ. MHRS IN SIM. (SEE NOTES): 662.16132
 E. UNUSED AVAILABLE MHRS (B-D): 2260.07868
 F. INDIRECT MANHOURS (SEE NOTES): 467.5584
 G. UNUSED AVAILABLE MHRS (E-F): 792.52028
 H. ADDITIVE TRANSFERABLE MHRS (SEE NOTES): 202
 I. MHRS REQ-POSITIVE/REMAINING-NEG (H-G) -1590.52028
 J. ADD. TRANS. MNPWR REQ. (J=I/MAF-I)0.J=0-I(0): 0
 K. ADDITIVE NONTRANSFERABLE MHRS (SEE NOTES): 0
 L. ADDITIVE NONTRANS MPWR REQ. (K/MAF): 0
 M. TOTAL FRACTIONAL MANPOWER REQ. (C+J+L): 9.45708737

B. $12 \times 8 \text{ HRS} \times 30.44 \text{ DAYS/M} = 2922.24$
 D. $1305.18 \text{ PSR MHRS} / 60 \times 30.44 \text{ DAYS/MONTH} = 622.16132$
 F. $2922.24 \times 0.16 = 467.5584$
 H. 202 ADDITIVE TRANS MHRS AS FOLLOWS:
 AGE HRS: 0
 SUPPLY SUPPORT HRS: 202
 LOCAL MANUFACTURE HRS: 0
 AIR BASE SUPT HRS: 0
 TRANSFERABLE PARTS SUPPORT: 0
 LOCATION SUPPORTED: 0 SUPPORT MHRS: 0
 K. NONTRANSFERABLE SHOP AND TDY SUPPORT MHRS: 0
 LOCATION SUPPORTED: 0 SUPT MHRS: 0 TDY HRS: 0

APPENDIX G: MANPOWER REQUIREMENTS BY AFSC

AFSC	MOB				MOB				SAVINGS (FOL)	SAVINGS (MOB)
	AC-130 ON EQP (FOL)	AC-130 OFF EQP	SOF130 ON EQP (FOL)	SOF130 OFF EQP	AC-130 TOTAL (MOB)	SOF130 TOTAL (MOB)				
321X3	8	5	7	3	13	10	-1	-3		
322X2	5	2	4	1	7	5	-1	-2		
325X1	6	2	6	1	8	7	0	-1		
328X0	13	5	14	4	18	18	1	0		
328X1	6	1	4	1	7	5	-2	-2		
328X3	10	6	10	5	16	15	0	-1		
328X4	5	1	4	1	6	5	-1	-1		
404X1	4	3	2	1	7	3	-2	-4		
423X0	10	4	12	5	14	17	2	3		
423X1	7	2	6	1	9	7	-1	-2		
423X3	8	3	8	3	11	11	0	0		
423X4	5	2	5	2	7	7	0	0		
426X3	19	16	19	16	35	35	0	0		
427X0	3	0	2	0	3	2	-1	-1		
427X1	2	0	2	0	2	2	0	0		
427X3	1	0	1	0	1	1	0	0		
427X5	4	8	4	9	12	13	0	1		
431X3	36	0	36	0	36	36	0	0		
431R3	13	0	13	0	13	13	0	0		
462X0	18	14	18	14	32	32	0	0		
462LO	7	0	7	0	7	7	0	0		
TOTAL	190	74	184	67	264	251	-7	-13		

APPENDIX H: DIRECT PRODUCTIVE MANPOWER COMPARISON

FAC	AFSC	LOCKHEED HURLBURT		AC-130		AC-130		SOF-130		NEW		ESTIMATE VS SOF-130 MOB
		MOB	ESTIMATE	FOL	MOB	FOL	MOB	FOL	MOB	FOL	MOB	
2E22	427X1	4		2	2	2	2	2	2	2	2	-2
2E23	423X3	5		7	11	7	11	7	11	7	11	+6
2E24	431R3	2		13	13	13	13	13	13	13	13	+11
2E32	462X0	14		0	15	0	15	0	15	0	15	+1
2G11	431X3	50		35	35	35	35	35	35	35	35	-15
2G12	321X3	13		8	13	7	10	7	10	7	10	-3
	322X28	13		5	7	4	5	4	5	4	5	-8
	325X1	6		6	6	6	6	6	6	6	6	0
	328X0	9		13	13	14	14	14	14	14	14	+5
	328X1	9		6	6	4	4	4	4	4	4	-5
	328X4	5		5	5	4	4	4	4	4	4	-1
	423X0	9		10	10	12	12	12	12	12	12	+3
	423X1	9		7	9	6	7	6	7	7	7	-2
	423X4	12		5	7	5	7	5	7	7	7	-5
	426X3	26		19	35	19	35	19	35	35	35	+9
2G13	462X0	28		25	25	25	25	25	25	25	25	-4
2R11	328X0	2		0	5	0	4	0	4	4	4	+3
	328X1	1		0	1	0	1	0	1	1	1	0
2R12	325X1	2		0	2	0	1	0	1	1	1	-1
2R13	328X4	2		0	1	0	1	0	1	1	1	-1
2R15	40471	2		4	7	2	3	2	3	3	3	+1
2R16	42350	1		0	4	0	5	0	5	5	5	+4
2R17	328X3	20		10	16	10	15	10	15	15	15	-5
2R30	42775	1		4	12	4	13	4	13	13	13	+12
2R31	427X4	2		1	1	1	1	1	1	1	1	-1
2R32	427X0	4		3	3	2	2	2	2	2	2	-2
TOTAL		251		190	264	184	251	184	251	184	251	

END

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